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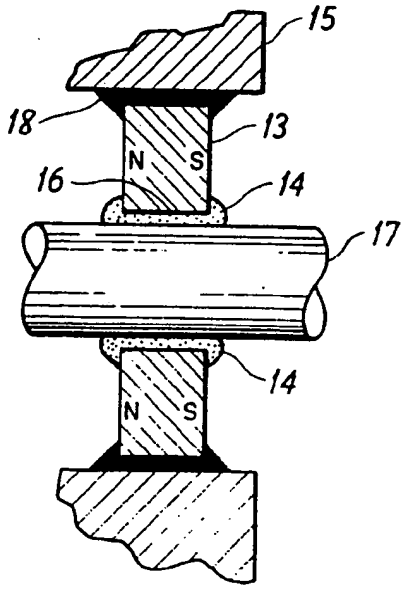
(54) Magnetic liquid shaft seal.

(57) A magnetic liquid shaft seal for forming a seal between a shaft (17) and a housing (15) through which the shaft extends comprises a permanent magnetic ring (13) which has its axis of magnetisation parallel to that of the shaft (17) and a ring of magnetic liquid (14). The ring (13) has its outer periphery fixed and sealed in the housing (15) and the ring of liquid (14) is held magnetically around the inner periphery of the ring (13) and in movable contact with the shaft (17). Alternatively the ring (13) may be fixed to the shaft (17) with the ring of liquid interposed between the ring (13) and the housing (15). A number of such sealing devices may be arranged in series along the shaft.



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FREDERICK D. EZEKIEL GJE 4079/183

MAGNETIC LIQUID SHAFT SEAL

The present invention relates to magnetic devices for forming a seal between a shaft and a housing.

Shaft seals which incorporate permanent magnets, pole pieces and magnetic liquids, hold the magnetic liquid captive between the pole pieces and other parts which move relative to each other to achieve complete sealing. Examples of such seals are disclosed in British Patent Specification No. 783,881 and U.S. Patent Specifications Nos. 3,620,584; 3,612,549 and 3,848,879.

These prior seals have successfully been used to seal against vacuum and sometimes against positive pressures of several hundred or more kN/m^2. Intricate multi-state seals are commercially available.

It is an object of this invention to provide a magnetic liquid shaft sealing device, which is compact and relatively easy and inexpensive to install.

According to this invention, a magnetic liquid sealing device for forming a seal between a shaft and a surrounding housing comprises a substantially circular permanent magnet which has its magnetic axis extending axially and is arranged to be sealed to the housing or the shaft, and a ring of magnetic liquid which is held magnetically around the periphery of the permanent magnet and is arranged to form a moving seal against the shaft or the housing respectively

or against a part which is fixed and sealed to the shaft or the housing.

It has been found that when a small amount of magnetic liquid is brought near the peripheral edge of an axially magnetized circular permanent magnet in the form of a disc or ring, the magnetic liquid distributes itself evenly all around the edge. The surface shape in cross-section of the liquid ring, which is thus formed, is determined by the magnetic flux lines between the opposite poles located one on each face of the magnet. In the case of a ring or washer, magnetic liquid will distribute itself around either the inner or the outer periphery, or both.

Thus, sealing can be achieved between either the outer edge of the ring or washer and an external housing, or between the inner edge and a shaft extending axially through the ring or washer, or between both edges at the same time. The stability of the seal is a function of several parameters, such as the gap, in which the liquid is located, between the permanent magnet and the adjoining surface, the magnetic permeability of the liquid, and the nature and strength of the permanent magnet.

Advantages of the invention include its extreme simplicity and low cost. The permanent magnet can be made quite thin, for example as little as 75 microns thick, so that it is inexpensive and can be used in narrow spaces where other seals cannot fit.

Furthermore, the sealing device can be used in conjunction with shafts and housings of magnetic or non-magnetic material. This is another advantage over existing magnetic liquid seals.

Because of its inherent simplicity, a sealing

device in accordance with the invention has a relatively low differential pressure holding capability and is useful as an exclusion seal.

Some examplesof sealing devices in accordance with the invention will now be described with reference to the accompanying drawings in which:-

Figure 1 is a diametric section through a circular magnet disc with magnetic liquid held around its perphery;

Figure 2 is a diametric section through a permanent magnet ring or washer with magnetic liquid held around its outer and its inner peripheries;

Figure 3 is a diagrammatic diametric section through a simple example of the device in accordance with the invention fitted between a rotary shaft and stationary housing;

Figure 4 is a view similar to Figure 3, but of a second example;

Figure 5 is a view similar to Figure 3, but of a third example;

Figure 6 is a view similar to Figure 3, but of a fourth example; and,

Figure 7 is a view similar to Figure 3, but of a fifth example.

With reference now to Figure 1, there is shown a diametric sectional view of a circular disc 11 made of a permanent magnet material. The disc 11 is magnetized with its magnetic axis extending axially of the disc. Magnetic liquid 12 is shown held magnetically around the circumferential edge of the disc 11.

Figure 2 shows a sectional view of a circular washer 13 made of permanent magnet material magnetized with its magnetic axi in the axial direction.

Magnetic liquid 12 is shown held magnetically around the outer circumferential edge of the washer 13. In addition, magnetic liquid 14 is shown held magnetically around the inner circumferential edge of the washer 13.

Figure 3 shows an example of a sealing device in accordance with the invention used to seal a rotary shaft 17 in a stationary housing 15. The magnetic ring or washer 13 is fixed and sealed to the housing 15. The shaft 17, which is rotatably mounted in the housing 15, protrudes through the central opening 16 in the permanent magnet ring 13. Magnetic liquid 14 is held between the outer surface of the shaft 17 and the inner circumferential edge of the ring 13, thus forming a seal between the ring 13 and the shaft 17 and hence between the shaft 17 and the housing 15. Adhesive sealant 18 permanently seals and fixes the ring 13 to the housing 15.

Figure 4 illustrates how the permanent magnetic ring 13 can seal around both its outer and inner circumferential edges. Captive magnetic liquid 12 forms a seal between the outer circumferential edge of the ring 13 and the housing 15, and further captive magnetic liquid 14 forms a seal between the inner circumferential edge of the ring 13 and the shaft 17.

In the example of Figure 5, several permanent magnetic rings 13 are arranged in series to achieve sealing against higher pressures. Each ring 13 is held in the housing 15, the end rings being sealed to the housing, and non-magnetic spacer rings 20 are fitted between the rings 13.

Figure 6 illustrates an embodiment of the invention for sealing a ball bearing. Here, permanent magnetic rings 13 are located one on each

side of a ball bearing 19. Magnetic liquid 14 held around the inner circumferential edges of the rings 13 forms a rotary seal against the shaft 27. A fixed seal 18 of each of the outer circumferential edges of the rings 13 to the housing 15 completes a sealed chamber around the ball bearing. Thus, the shaft 17 can rotate without introducing a leak path to the bearing 19.

Figure 7 illustrates another arrangement for sealing a ball bearing. In this example, the inner and outer reces of the ball bearing 19 are axially elongated to accommodate magnetic rings 13. Magnetic liquid 14 is held on the inner circumferential edge of each ring 13 and forms a moving seal against the inner bearing race. The outer circumferential edge of each ring 13 is fixed and sealed to the outer race of the bearing 19 as shown at 18. Alternatively the ring 13 may be fixed and sealed to the inner race and have magnetic liquid forming a moving seal against the outer race.

The permanent magnetic ring or disc may have an axial thickness of from 75 to 2600 microns and it may be made of nylon filled with ferrite.

CLAIMS

1. A magnetic liquid sealing device for forming a seal between a shaft (17) and a surrounding housing (15), the device comprising a substantially circular permanent magnet (11, 13) which has its magnetic axis extending axially and is arranged to be sealed to the housing (15) or the shaft (17), and a ring of magnetic liquid (12, 14) which is held magnetically around the periphery of the permanent magnet (11, 13) and is arranged to form a moving seal against the shaft (17) or the housing (15) respectively or against a part which is fixed and sealed to the shaft or the housing.

2. The combination of a rotary shaft and a sealing device in accordance with Claim 1, the shaft (17) having its peripheral surface in contact with the liquid (14).

3. The combination of a shaft, a housing, which surrounds the shaft and in which the shaft is rotatable, and sealing device in accordance with Claim 1 forming a seal between the shaft (17) and the housing (15), wherein the permanent magnet is a ring (13) which surrounds the shaft (17) and has one of its peripheries fixed and sealed to the housing (15) or the shaft (17) by sealing means (12, 18) and the magnetic liquid (14) held around its other periphery and in movable contact with the shaft (17 or the housing (15) respectively.

4. The combination according to Claim 3, in which the sealing means (18) is fixed sealing means which fixes the outer periphery of the ring to the housing.

5. The combination according to Claim 3,

in which the sealing means (12) comprises a second ring of magnetic liquid (12) held magnetically around the outer periphery of the ring (13), whereby relative rotation can take place between the ring (13) and the housing (15).

6. The combination according to any one of Claims 2 to 5, in which there are a plurality of the permanent magnets in the form of rings (13) spaced apart along the shaft (17), each of the rings (13) having a ring of magnetic liquid (14) held around its inner periphery in contact with the shaft (27).

7. The combination according to Claim 6, in which there is a ball bearing (11) supporting the shaft between the rings (13).

8. A sealing device according to Claim 1, or the combination according to any one of Claims 2 to 7, in which the permanent magnet has an axial thickness in the range of from 75 to 2600 microns.

9. A sealing device or the combination in accordance with any one of the preceding Claims, in which the permanent magnet comprises nylon filled with ferrite.

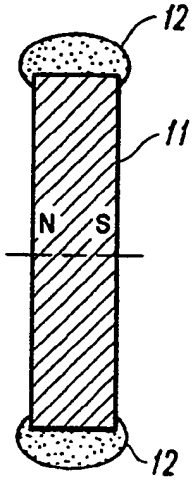

FIG. 1

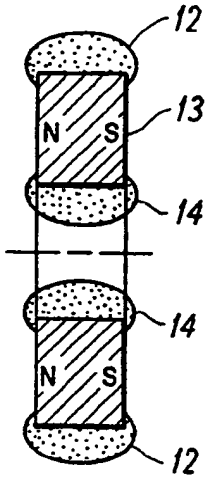

FIG. 2

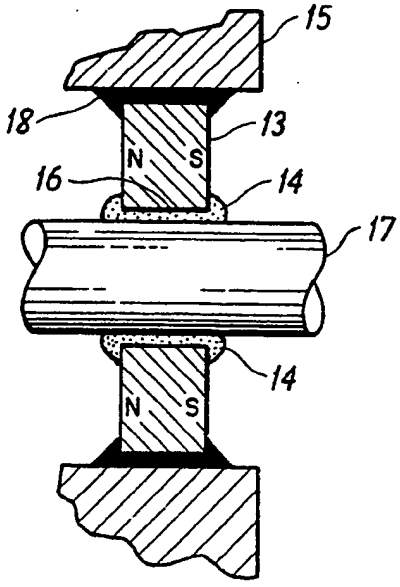

FIG. 3

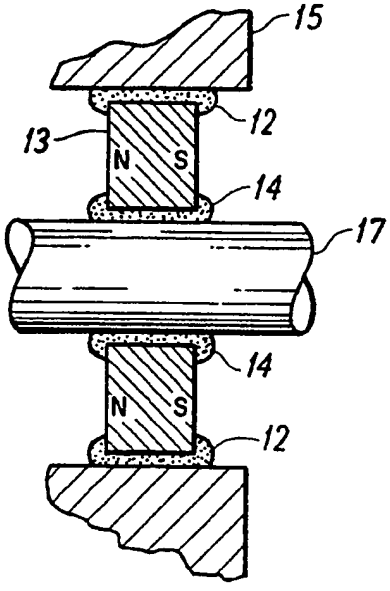

FIG. 4

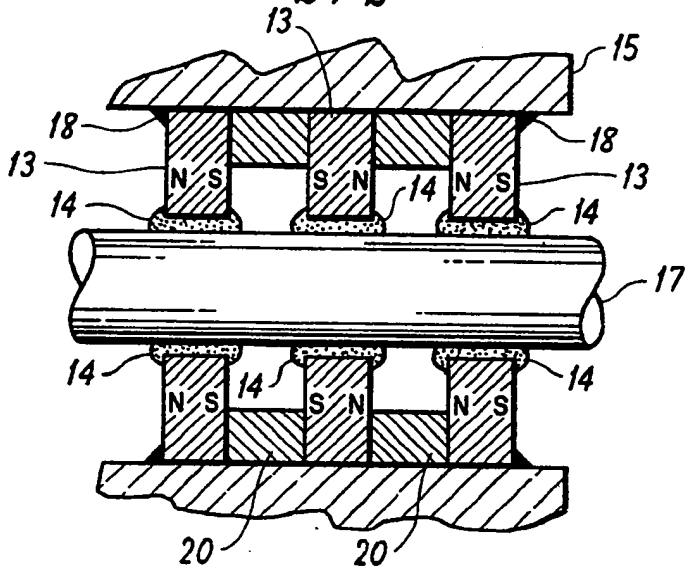

FIG. 5

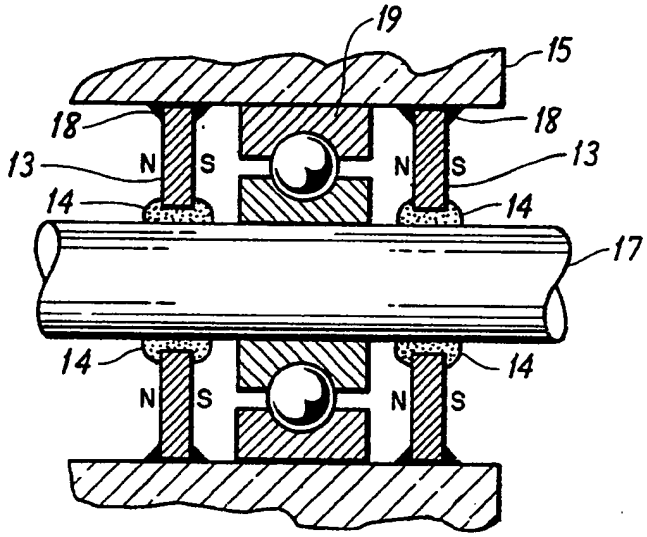

FIG. 6

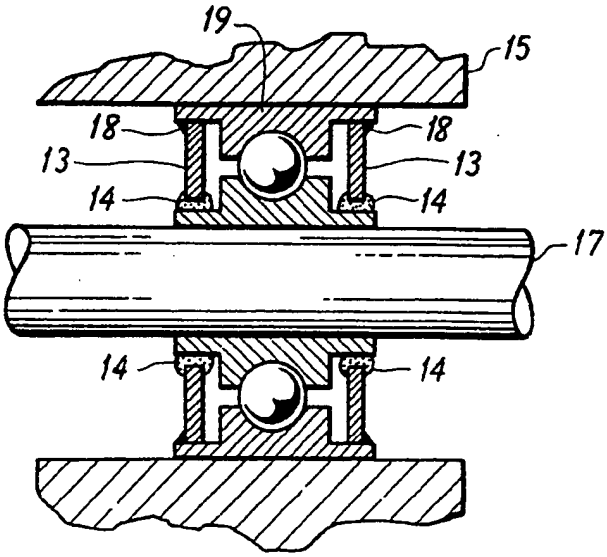

FIG. 7

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EUROPEAN SEARCH REPORT

0012556
Application number

EP 79 302 786.3

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	US - A - 2 557 140 (A. RAZDOWITZ) * column 5, lines 19 to 35; fig. 1, 7 *	1,2,6 7
	US - A - 2 974 981 (W.L. VERVEST et al.) * claim; fig. 1 and 2 *	1
	H. REINBOTH "Technologie und Anwendung magnetischer Werkstoffe" 1970, VEB VERLAG TECHNIK, Berlin page 351 * page 351, lines 35 to 38 *	9
A	DE - A1 - 2 628 831 (MACHINENFABRIK AUGSBURG-NÜRNBERG AG) * entire document *	
A	US - A - 3 740 060 (G. MISKOLCZY et al.) * entire document *	
A,D	GB - A - 783 881 (METROPOLITAN-VICKERS ELECTRICAL CO. LTD.) * entire document *	
A,D	US - A - 3 612 549 (M.H. BERKOWITZ) * entire document *	
A,D	US - A - 3 620 584 (R.E. ROSENSWEIG) * entire document *	

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CLASSIFICATION OF THE APPLICATION (Int. Cl.)

F 16 J 15/40
F 16 C 33/82

TECHNICAL FIELDS SEARCHED (Int.Cl.)

F 16 C 33/00
F 16 J 15/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	20-02-1980	MASSALSKI

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EUROPEAN SEARCH REPORT

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- page 2 -

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
A,D	US - A - 3 848 879 (W.A. HUDGINS) * entire document *	

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

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